

# Geothermal technologies

U.S. Department of Energy

## The New Geothermal Program

The DOE Geothermal Energy Program builds on a history of accomplishments that has facilitated a six-fold growth in geothermal power capacity in the United States. DOE funds research to reduce the cost of geothermal components, systems, and operations. The DOE program helps the industry maintain its technical edge in world energy markets, thereby enhancing exports of U.S. goods and services, and encouraging U.S. job growth.

During the last year, a reorganization of DOE's Office of Power Technologies went into effect. With this reorganization, the Office of Geothermal Technologies was combined with the Wind Energy Program. In addition, R&D activities pertaining to geothermal heat pumps have been curtailed due to the market success that has been realized by this technology during the last decade.

The mission of the Geothermal Energy Program is to work in partnership with U.S. industry to establish geothermal energy as an economically competitive contributor to the U.S. energy supply. Although the present industry is based on hydrothermal resources, the long-term viability of geothermal energy lies in developing technology to enable use of the full range of geothermal resources.

Industry is interested in R&D that will lead to solutions to immediate and pressing technological problems. As a result, DOE undertakes a program balanced between short-term goals of greater interest to industry, and long-term goals of importance to national energy interests.

Geothermal facilities use the natural heat in the earth's interior to produce electricity or to satisfy other heat energy needs. Currently, the installed commercial geothermal electric capacity in the United States is about 2,800 MW. Other non-electric uses of geothermal energy total 600 MW. The potential to produce sustainable, environmentally sound geothermal energy is much greater, especially in the western United States.

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### Program Goals and Objectives

- **Double the number of states with geothermal electric facilities to eight by 2006**
- **Reduce the levelized cost of generating geothermal power to \$0.03 to \$0.05 per kilowatt-hour by 2007**
- **Supply the electrical power or heat energy needs of 7 million homes and businesses in the United States by 2010**



A geothermal power plant near El Centro, California.  
Photo by Warren Gretz, NREL

The Program's R&D activities closely align with its mission and goals. With improved exploration methods, industry will locate and characterize new geothermal fields more accurately, reducing the high cost and risk of development. Better technology for drilling wells will make it possible to access deeper resources and reduce costs, thereby expanding the economic resource base. Advances in energy conversion will establish air-cooled binary technology as a means of generating competitively priced electricity from more plentiful lower-temperature resources. Studies of reservoir behavior will improve management of geothermal fields, allowing fields to operate for over 100 years as sustainable commodities. These activities all contribute directly to reducing the cost of geothermal development and enabling the installation of more geothermal facilities.

Geothermal electric generation projects are capital-intensive enterprises, with the major expenses being incurred before the plant begins to produce revenue. The high-cost components of a geothermal development project include: drilling exploration, production, and injection wells; and plant equipment and construction. The primary risk in a geothermal project is confirmation of a viable reservoir, which usually requires extensive drilling and well testing. To help reduce the risks and costs in geothermal development, the Program's research strategy involves:

- Improving technologies for exploration, detection of fractures and permeable zones, well siting, and fluid injection
- Decreasing the cost of drilling and completing geothermal wells
- Reducing the capital, operation, and maintenance costs of geothermal power plants.

A new initiative announced in January 2000, *GeoPowering the West*, will lend strong support toward achieving the Program's goals. The initiative will provide Federal leadership, public awareness and education, technology development, and policy support that will enable broad expansion in the use of geothermal resources throughout the western United States.

The R&D program is based upon DOE's interaction with industry stakeholders and geothermal experts at universities and the national laboratories to create a balanced portfolio of core research and well-focused technology development thrusts. Cost-shared activities in geoscience, drilling, and energy systems research leverage the Federal funds and facilitate technology transfer. These three key activity areas are described below.

## GEOSCIENCE AND SUPPORTING TECHNOLOGIES

**Core Research**—Core research is being conducted in the areas of materials, geofluids, geochemistry, geophysics, rock properties, and reservoir modeling. The work ensures

that the United States continues to lead the world in geothermal science and technology, while expanding the geothermal knowledge base. Core research provides the understanding of complex geothermal processes and facilitates development of suitable technology for exploiting geothermal resources.

**Enhanced Geothermal Systems**—The Enhanced Geothermal Systems (EGS) project will apply hydraulic injection and fracture mapping technologies to both new and operating geothermal fields in the United States. The project applies EGS technology (i.e., rock fracturing, water injection, and water circulation) to sweep heat from the unproductive areas of existing geothermal fields, or new fields lacking sufficient production capacity.

**University Research**—The Program supports researchers at universities to expand their geothermal knowledge base in the areas of heat flow and temperature gradient research; reservoir dynamics and two-phase flow; the stress and thermal history of fractures; active faulting areas; and the history of plutonic hydrothermal systems. This research complements core research conducted by national laboratories and industry.

**Seismic Exploration**—Building on the design and testing of seismic source instruments to generate seismic energy, researchers in collaboration with industry are developing 3-D seismic exploration methods. The technology is used routinely in the oil and gas industry, but the generally poor seismic reflection properties of geothermal fields requires extensive adaptation for geothermal use. If successful, the technology will become the tool of choice for precisely locating geothermal fields.

**Detection and Mapping**—Mapping of geothermal fields and detection of open fractures and permeable zones are critically important to the overall productivity of a geothermal well field. Exploration projects with industry are used to find and confirm new geothermal resources in the United States. Researchers use tracers to determine the flow paths of injected water through a geothermal reservoir, analyze fractures with a borehole televiewer which takes pictures of the fractures in a well, and analyze rock cores for correlation with seismic exploration data. In addition, researchers detect fractures with seismic shear-wave splitting, develop new software to interpret downhole electromagnetic data, and conduct geologic mapping of existing geothermal fields.

## DRILLING RESEARCH

**Innovative Subsystems**—When completed, the Geothermal Advanced Drilling System will provide dramatic improvements in the economics of drilling wells in deep, hard, and fractured hot rock. This system will consist of a number of unproven and innovative subsystems. Subsystems currently under development include lost circulation control, hard-rock drill bits, high-temperature well sampling and monitoring instrumentation, and wireless data telemetry. Work on subsystem development is

performed with careful attention to integration of components into a complete advanced drilling system.

**Near-Term Technology Development**—Incremental improvements to existing technology continues while development of the Geothermal Advanced Drilling System takes place. These drilling improvements, which involve cost-shared projects with industry, include a valve-changing assembly, downhole motor stator, foam cements, and a percussive mud hammer.

**Diagnostics-While-Drilling**—The principal subsystem component of the Geothermal Advanced Drilling System is a high-speed data link that can provide drilling data and information about rock characteristics to the surface in real time for better decision making by drillers. With the completion of a reliable data link, other components of the subsystem that rely on the flow of high-quality data, such as bit sensors, can be developed.

## ENERGY SYSTEMS RESEARCH AND TESTING

**Advanced Plant Systems**—Development of new technology for generating electricity from geothermal resources continues. Areas of investigation include air-cooled condensation of binary working fluids, control of heat exchanger fouling, and instrumentation for process monitoring.

**Small-Scale Field Verification**—Several prototype systems will be constructed and field tested to establish the performance characteristics of small-scale geothermal power plants and the economic benefits of improved electric power generation technology in geothermal applications.

**GeoPowering the West**—*GeoPowering the West* is a major new initiative that will foster awareness of the availability and benefits of geothermal energy throughout the western United States where geothermal resources are most readily accessible. The initiative will begin with education, awareness, and outreach activities aimed at a variety of stakeholders, such as businesses, government organizations, Native American groups, and the general public.

**International Clean Energy Initiative**—Exceptional opportunities exist for increased use of geothermal resources in overseas markets. Combined heat and power, hybrid systems, distributed power, and off-grid applications all present means for harnessing more geothermal energy. The Program assists U.S. industry in identifying potential new markets in developing and transitional countries.

**Industry Support**—The Program provides support to the U. S. geothermal industry in resolving near-term technical and institutional problems and enhancing technology transfer for both low and high temperature systems. Geothermal applications in a variety of situations, ranging from small-scale systems to traditional central stations,

will be assessed for technical, economic, and institutional feasibility.

Geothermal resources are domestic resources. Keeping the wealth at home translates to more jobs and a robust economy. And not only does our national economic and employment picture improve, but also a vital measure of national security is gained when we control our own energy supplies.

Together, geothermal power plants and direct-use technologies are a winning combination for meeting our country's energy needs while protecting the environment. Whether geothermal energy is used for producing electricity or heat, it's a clean alternative for the 21st Century.

## GeoPowering the West—

### What's It All About

*GeoPowering the West* is a new initiative to capitalize on the abundant geothermal resources found in the West, including Alaska and Hawaii. The communities of the West are poised to take advantage of the economic stimulus that this locally produced clean power can provide. This initiative will provide new sources for generating electric power and space heating, crop processing, and aquaculture. In turn, this will fuel sustainable economic development, create jobs in rural areas and on Native American lands, and support cleaner local and regional environments. Geothermal energy is the perfect complement to the pioneering and self-reliant spirit that is the American West.

### — What is GeoPowering the West? —

**It's a commitment to dramatically increase the use of geothermal energy in the western United States.**

Geothermal energy is already a significant supplier of electricity to the western grid, with 2800 MW installed in California, Nevada, Utah, and Hawaii. These states are just the beginning. Existing and improved technology for geothermal heat reservoir discovery and recovery will allow a broadening to the entire West. We are just beginning to understand the extent of this resource base. Recent studies have identified nearly 300 western communities in 10 states with potentially useable geothermal resources within 5 miles. The potential for expansion clearly exists, and *GeoPowering the West* will bring clean, cost-effective geothermal energy to cities from Albuquerque to Seattle.

*GeoPowering the West* will provide the impetus required to not only expand the use of geothermal energy for electricity production but to encourage the broader use of more widely available low-temperature resources. Through

*GeoPowering the West*, the United States will achieve targeted regional economic development, protect the local environment, reduce air pollution, lessen the risks of global climate change, and increase energy security.

## —Strategies for *GeoPowering the West*—

- **Increase the use of geothermal for electricity production, through identification and development of new sites, expansion of existing reservoirs, strengthening of technology development efforts, and an effort to tap more-localized resources for small-scale distributed power**
- **Use the largely untapped lower temperature resources that are broadly available across the western states to supply heating for residences and commercial establishments, and for industrial process applications**

The initiative will seek to expand the public's understanding of how geothermal resources can meet their energy needs. It will achieve these goals by building on current and future public and private sector efforts to develop geothermal power. A vigorous R&D agenda will be pursued to bring new technology to fruition. The initiative supports DOE's plan to have 25,000 MW of non-hydropower renewable generating capacity on-line by 2010. In addition, it supports the Western Governors' Association and Western Regional Air Partnership's goal of increasing the contribution of non-hydropower renewable energy to regional electricity needs to 10% by 2005 and to 20% by 2015, as a means of reducing certain forms of air pollution in the West.

## Goals

The goals of *GeoPowering the West* are to:

- **Double the number of states with geothermal electric power facilities to eight by 2006**
- **Supply the electrical power or heat energy needs of at least 7 million U.S. homes by 2010**
- **Provide 10% of the electricity needs of the western states by 2020.**

*GeoPowering the West* will be a partnership of a variety of organizations from both the private and public sectors, and will serve as a focal point for the efforts of a wide range of stakeholders, representing all elements of the supplier, user and environmental communities. *GeoPowering the West* will reach out to new constituents, to provide an

opportunity for participation by other interested parties from agricultural, Native American, and other rural communities.

## —Benefits of *GeoPowering the West*—

- **\$50 billion in capital investment in the western states over 20 years**
- **\$500 million in new income for western land-owners over 20 years**
- **\$5 billion in annual capital investment in 2020**
- **Diversification of power generating options as an alternative to aging coal-fired power plants**
- **Significant amounts of air pollutants, carbon emissions, and particulates that contribute to the health and air-quality problems of the region are displaced**

Local partnerships are essential to the initiative's success. The DOE Regional Offices will work with these local groups to ensure that appropriate resources are available. The Geothermal Resources Council and the Geothermal Energy Association will participate in planning and execution activities to capitalize on the links to key stakeholder sectors already established.

## Implementation Strategies for *GeoPowering the West*

- **Provide Federal leadership in geothermal use**
- **Build regional partnerships to tap local resources**
- **Explore new technologies and applications**
- **Educate the American public**

## ACTION ITEMS

A number of actions have been identified as central to *GeoPowering the West*. These comprise a six-point plan for implementing the initiative:

**1. Education and Outreach:** Build regional awareness of geothermal's benefits to stimulate consumer demand for all forms of geothermal energy. The regional public will be informed about how geothermal can provide locally generated electricity. Consumers should understand that their ability to choose clean energy sources can have

profound implications for the environment. Potential developers of geothermal projects and regulators will be provided with decision tools that allow them to evaluate geothermal as an option for their situation. Geothermal electricity and thermal sources will be fostered as an important alternative for “green” customers seeking, and willing to pay more for, clean sources of energy.

*GeoPowering the West* will bring these messages to the American public through an educational effort built around a core of both technical and nontechnical materials prepared for this purpose. With the emergence of the Internet as a primary medium for communication, *GeoPowering the West* will maintain a Web site ([www.eren.doe.gov/Geopoweringthewest](http://www.eren.doe.gov/Geopoweringthewest)), with a mailing list capability, for information dissemination. The Web site will be updated regularly and will be heavily oriented toward telling the stories of the people and places where geothermal is making a difference. The initiative will also undertake secondary school and university/college partnerships to develop programs that will increase student, teacher, and community awareness of geothermal energy.

Program meetings will be held periodically with partners and stakeholders to both facilitate sharing of information and to provide recognition, such as awards, for their efforts. These meetings, which will be held in the target regions, will be an important mechanism for maintaining program momentum.

**2. Federal Participation:** Increase Federal geothermal use to promote technological maturity. Federal facilities offer many opportunities for geothermal system use. A commitment by Federal agency management to use geothermal energy will be required to realize the full potential of this opportunity. The recently released Executive Order on “Greening the Government Through Energy Efficiency Management” orders each agency to strive to expand its renewable energy use by installing renewable energy systems and buying electricity produced by renewable energy systems. Each agency’s success in using renewable energy will be taken into account in assessing the agency’s progress and contribution.

The Federal Energy Management Program will serve as the primary focus of *GeoPowering the West’s* outreach to Federal agencies. However, the Departments of Defense, Agriculture, and Interior are natural partners who already have experience with geothermal systems.

Programs will be implemented that help these agencies identify their most cost-effective opportunities for geothermal. Some of these may be to use geothermal on-site to provide for their own electricity or heat needs. Others may involve providing access to Federal lands with geothermal resources to private developers. Technical expertise will be provided to guide these agencies throughout the process to ensure that their investments in geothermal systems yield maximum return to the agency and the public. By providing an expanding early



*Environmentally compatible, clean energy for the 21st Century from geothermal energy. Photo courtesy of GRC*

market for geothermal systems, the Federal government can help build a base of experience with the technology that will come with wider deployment.

**3. Technology Advancement and Deployment:** Support the development and use of new technologies that will increase the economic competitiveness of geothermal energy. The initiative will maintain a robust program of technology development with industry to enable the use of geothermal energy at the lowest possible cost. Industry-driven priorities will continue to help guide the Federal geothermal research program. New sources of geothermal power, such as Enhanced Geothermal Systems, will be pursued vigorously. Research projects will be identified by industry and performed in partnership with the Federal government through cost-shared R&D. Contracts with industry and the academic community will ensure the broadest possible participation by the geothermal community.

Small geothermal installations (less than 5 MW) have many possible applications, including remote generation. *GeoPowering the West* will support the deployment of new innovative geothermal technology at new sites as a means of verifying that technology while encouraging additional power development on a number of fronts. It will provide continued support for technology development.

**4. Exploration and Confirmation:** Expand opportunities for new developments through a resource prospecting and discovery effort. The program will cooperate with other state and Federal agencies, such as the United States Geological Survey, Forest Service, Bureau of Land Management, and the Department of Defense, to identify geothermal resources that have no obvious surface expression. An emphasis will be placed on geographic diversity across the western states. A matching fund for exploratory drilling will be evaluated as one way to lower risks for the geothermal industry and to build momentum, especially for smaller and direct-use applications.

**5. Policy Incentives:** Foster appropriate policy choices to provide a supportive investment environment. A number of policies that support geothermal could be implemented, at both the state and Federal levels. The program will work closely with the U.S. geothermal industry, with state and regional governments, with energy commissions, and with DOE policymakers to investigate and rank policies that would be the most helpful in fostering geothermal development. These policies must be consistent with the goals of restructuring and consumer choice. A 10-year royalty holiday from payments to the Federal government for new geothermal development on Federal lands is one such policy option. A Renewable Portfolio Standard, or minimum required level of use, would provide initial market momentum. A performance tax credit for small systems, or for repowering known geothermal resources, would lend added impetus for that market. Encouraging state public utility commissions to examine the full costs associated with conventional fuels (so-called externalities) is another area of potential policy emphasis. *GeoPowering the West* will develop information on these policies.

**6. Institutional Improvements:** Encourage a regulatory and business climate conducive to geothermal development. Despite a positive record of performance with little or no environmental problems, greater use of geothermal energy has often been hampered by institutional issues, e.g., land use, aesthetics, and natural and historic site preservation raised by regulatory agencies or concerned members of the public. Oftentimes, these issues can be settled through education, negotiation, and the application of mitigation measures.

In some parts of the West, areas with excellent geothermal resources are located far from major electrical load centers. In these cases, a shortage of electrical transmission capacity can become a major constraint to development. The initiative will seek opportunities to work with local and regional stakeholders to improve transmission-system capacity and reliability by relieving transmission bottlenecks. The Western Area Power Administration and Bonneville Power Administration are natural partners for this effort. The initiative will assist local stakeholders as they work with financial and government institutions to ensure that geothermal energy projects are not unduly hindered by barriers to their use.

Through efforts to lower institutional barriers and speed approval processes, the cost of borrowing should decline as perceptions of risk are reduced. A model roadmap for local officials to use in the approval process would facilitate this risk reduction. Interconnection issues will be investigated to determine if their impacts on geothermal use are significant, and, if so, to identify further work that might be undertaken to overcome that barrier.

For more information, please visit our Web site at <http://www.eren.doe.gov/geopoweringthewest/> or contact the DOE Geothermal Energy Program at 202-586-5340.

## DOE's New

## Geothermal Program Focus—

## Three Major Solicitations

### DOE SEEKS INDUSTRY PARTICIPATION IN GEOTHERMAL ENERGY R&D

Secretary of Energy Bill Richardson recently announced the availability of about \$50 million in clean energy solicitations, over about a five-year period, for geothermal energy development. These solicitations will be cost-shared with industry participants and the resulting work will lead to a better understanding of domestic geothermal resources and the development of technology that will expand the use of geothermal energy.

The program currently seeks industry applicants for projects in the areas of small-scale geothermal electric power plants, enhanced geothermal systems (EGS), and geothermal resource exploration and definition. All three of these development areas will complement DOE's new *GeoPowering the West* Initiative. As Secretary Richardson said in his prepared remarks on January 24 regarding the *GeoPowering the West* Initiative:

*"We've gotten a taste of what geopower can offer to our country. Now we will seek to push its development along. We will seek to summon new interest, new money, and more companies to develop this resource that lies under our own feet, ready to help fuel America's prospects in the next hundred years."*

### SMALL-SCALE GEOTHERMAL ELECTRIC POWER PLANTS

The National Renewable Energy Laboratory has issued a request for proposals (Solicitation No. RAA-0-30429) on a new project to research and develop small-scale geothermal power plants. The project has two primary objectives: to test and evaluate, in various locations, the performance and operational characteristics of small-scale geothermal electric power plants; and to determine their ability to provide distributed power in the western United States.

"Small-scale" geothermal power plants are considered to be those that have approximate net electrical outputs of between 300 kW and 1 MW. The project will be conducted under a cost-sharing type contract with three phases. Phase I includes permitting, zoning, and other regulatory requirements; preliminary design; well development

(only if necessary); resource characterization; performance monitoring and evaluation plan; market development; and Phase I presentation. Phase II includes financing, detailed plant design, construction management plan, permitting, and Phase II presentation. Phase III includes power plant construction, instrumentation, startup/check-out, operation and performance monitoring and evaluation, and information dissemination. Multiple awards are anticipated under the Fiscal Year 2000 funding level of \$750,000 to fund Phase I work. Funding for Phases II and III is not currently available. Cost sharing in the minimum amount of 20% is required from offerors.

The deadline for receipt of applications is COB June 22, 2000. For more information, please visit the Geothermal Energy Program Web site at <http://www.eren.doe.gov/geothermal/geosolicitations.html>.

## ENHANCED GEOTHERMAL SYSTEMS

The DOE Idaho Operations Office recently released a solicitation for projects that support the development of efficient, cost-effective EGS technology. Phase I consists of preparing a conceptual definition for field verification of the EGS technology. Phase I will provide credible, comprehensive, cost-conscious, business-oriented conceptual designs for an EGS, which could be successfully located at a U.S. geothermal site. The conceptual study will discuss the proposed technology and the geo-technical and resource characteristics of the site that will lead to successful field verification and testing of the technology. The study must show that the application of the proposed technology is likely to succeed at this site. Economic studies should be sufficiently detailed that project development-cost estimates are credible. Ten financial awards, up to \$200,000 each, will be made for Phase I. The period of performance for Phase I is anticipated to be four months.

Upon evaluation of the results from Phase I studies, DOE will select the most promising projects for Phase II awards. Offerors must provide a minimum 20% cost sharing during Phase II; larger amounts of cost sharing are encouraged. Phase II will involve field verification. This solicitation was the only solicitation for this effort, and at least one award is reserved for small business. The Program's goal is to partner with the geothermal industry to install at least 10 MW of electrical capacity using EGS technology by 2006.

More information can be found at: <http://www.id.doe.gov/doeid/PSD/proc-div.html>; then select "Current Solicitations and Sources Sought," and search through "DE-PS07-00ID13913."

## GEOTHERMAL RESOURCE EXPLORATION AND DEFINITION

The DOE Albuquerque Operations Office has issued a solicitation for projects to develop collaborative efforts that support the exploration and development of new, previously undiscovered geothermal resources, thereby increasing the amount of geothermal energy available for



*One of DOE's solicitations supports the development of geothermal resources, which includes drilling.*

*Photo by Warren Gretz, NREL*

electric power generation. Previously undiscovered geothermal resources are designated as specific areas for emphasis in this effort. Projects may consist of up to three phases: (1) Phase I includes the performance of surface exploration to discover a probable geothermal resource and select a site for drilling a geothermal exploration well; (2) Phase II consists of the drilling of a slim-hole (six-inch diameter or less) exploration well and the compilation of drilling and temperature data to further confirm the resource; and (3) Phase III includes the testing of the well

to define the reservoir and confirm the resource. The period of performance is expected to last three years for all three phases. Each project will be cost-shared with the participant providing a minimum of 20% of the costs (at least 10% must be for direct costs and not in-kind contributions). DOE will share up to 80% of exploration, well drilling, and well testing (resource definition) costs. The estimated DOE FY00 funding for this program is \$900,000.

For questions related to all aspects of this solicitation, contact the DOE-AL, Contracts and Procurement Division, Technical Operations Support Team, P.O. Box 5400, Albuquerque, NM 87185-5400. Inquiries should be addressed to the attention of Nancy R. Hoffman, Contracting Officer (CO) (phone: 505-845-4127; fax: 505-845-5181; and e-mail: [nhoffman@doeal.gov](mailto:nhoffman@doeal.gov)). The control number assigned is Solicitation No. DE-RP04-00AL66843.

*For more information on these solicitations and the DOE Geothermal Energy Program, as well as for links to the actual solicitations and other background information, visit the Program Web site at <http://www.eren.doe.gov/geothermal/>, or visit the GeoPowering the West Web site at <http://www.eren.doe.gov/geopoweringthewest/>.*

**\$4.8 Million**

**in Geothermal Grants**

Over \$4.8 million will be awarded for geothermal activities in six western states including Nevada, California, Texas, Utah, Idaho, and North Dakota. Secretary of Energy Bill Richardson announced this at a January 24 news conference on Capitol Hill. The funding will be used to

provide technical assistance to support the design and testing of new geothermal technology. This includes approximately \$4.4 million recently awarded for geothermal reservoir technology research, development, and demonstration.

The research activities are directed towards the domestic use and development of new technologies for geothermal reservoir exploration, characterization, and management. This research will provide developers information on identifying the size of the resource, how good the resource is, and how best to keep the resource viable. Ten awards were made for the following projects.

Four 3-year grants were made to the University of Utah totaling about \$3.3 million for the following activities:

- Characterize and evaluate geothermal fields in the western United States
- Improve hardware and software for electromagnetic imaging of geothermal reservoirs
- Develop tracers, tracer detection techniques, and numerical models to characterize fracture flow in geothermal reservoirs
- Use well samples, core, and other data from geothermal systems to better understand the characteristics, behavior, and geometry of these systems.

Another grant was made to the University of North Dakota for \$383,000 to develop a computer code for modeling the geometry of hydraulically driven fractures.

One 3-year grant was awarded to the Southern Methodist University, in Texas, for \$391,076 to analyze the geological and geophysical data from Dixie Valley, Nevada, to develop a model for Basin and Range Systems in general that can be used for exploration; and to enhance the geothermal database in the western United States.

One 2-year grant of \$174,050 was given to Dr. Denis L. Norton in Idaho to improve interpretations of hydrothermal systems heated by granites to develop exploration strategies for industry.

Geomechanics International, Inc., in California received a one-year grant for \$150,380 to develop techniques for determining the relationship between stress and productivity in a fracture-dominated geothermal reservoir at Dixie Valley, Nevada. Work will be done in Nevada.

Two recent awards were made under DOE's Geothermal Power Initiative, which targets cost-shared research projects that promote commercialization of geothermal energy and that result in a near-term increase in the amount of electrical power generated from geothermal energy in the United States. The Northern California Power Agency (consisting of 10 municipal power agencies) in Middletown, California, received \$250,000 to develop and implement guidelines and roadmaps for geothermal power plants to reduce maintenance costs; and to increase reliability, efficiency, and competitiveness. Thermochem, Inc. in Santa Rosa,

California, was awarded \$145,892 for a project to provide alternatives to water washing for impurity removal from superheated geothermal steam.

## ADCC Researchers

### Receive Award

On May 10, researchers at DOE's National Renewable Energy Laboratory (NREL) received a "2000 Federal Laboratory Consortium Award for Excellence in Technology Transfer" for the Advanced Direct-Contact Condenser (ADCC) as applied in geothermal power plants. The award recognizes individuals at Federal laboratories whose work exemplifies the power of successful government-industry partnerships.

The Geothermal Energy Program provided funding for the ADCC research, which was conducted by an NREL research team that included Desikan Bharathan, who developed the technology, Vahab Hassani, Yves Parent, Federica Zangrando, and Ed Hoo. The ADCC was first demonstrated at The Geysers in California at a geothermal power plant operated by the Pacific Gas & Electric Company. ABB ALSTOM Power of Easton, Pennsylvania, is now marketing the technology. An ADCC will soon be installed at the new Tres Virgenes Geothermal Power Plant in Mexico.

This is the ADCC's second award. In 1999, it also received one of the year's "R&D 100 Awards" from *R&D Magazine*.

The Consortium, or FLC, was organized in 1974. It was formally chartered by the Federal Technology Transfer Act of 1986 to promote and to strengthen technology transfer nationwide. Today, the FLC includes more than 600 major Federal laboratories, centers, departments, and agencies as members.

*NREL researcher Desikan Bharathan works on a computer model of the ADCC, which is designed to boost geothermal power.*

*Photo by Dave Parsons, NREL*



## How to Reach Us

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